I-03-2

# INSTRUCTION MANUAL
# MODEL P-350

## DIGITAL STRAIN INDICATOR
## (PORTABLE)

THE Budd COMPANY

INSTRUMENTS DIVISION

PHOENIXVILLE, PA.

SERIAL NO 003997

I-03-2

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# MODEL P-350

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# (PORTABLE)

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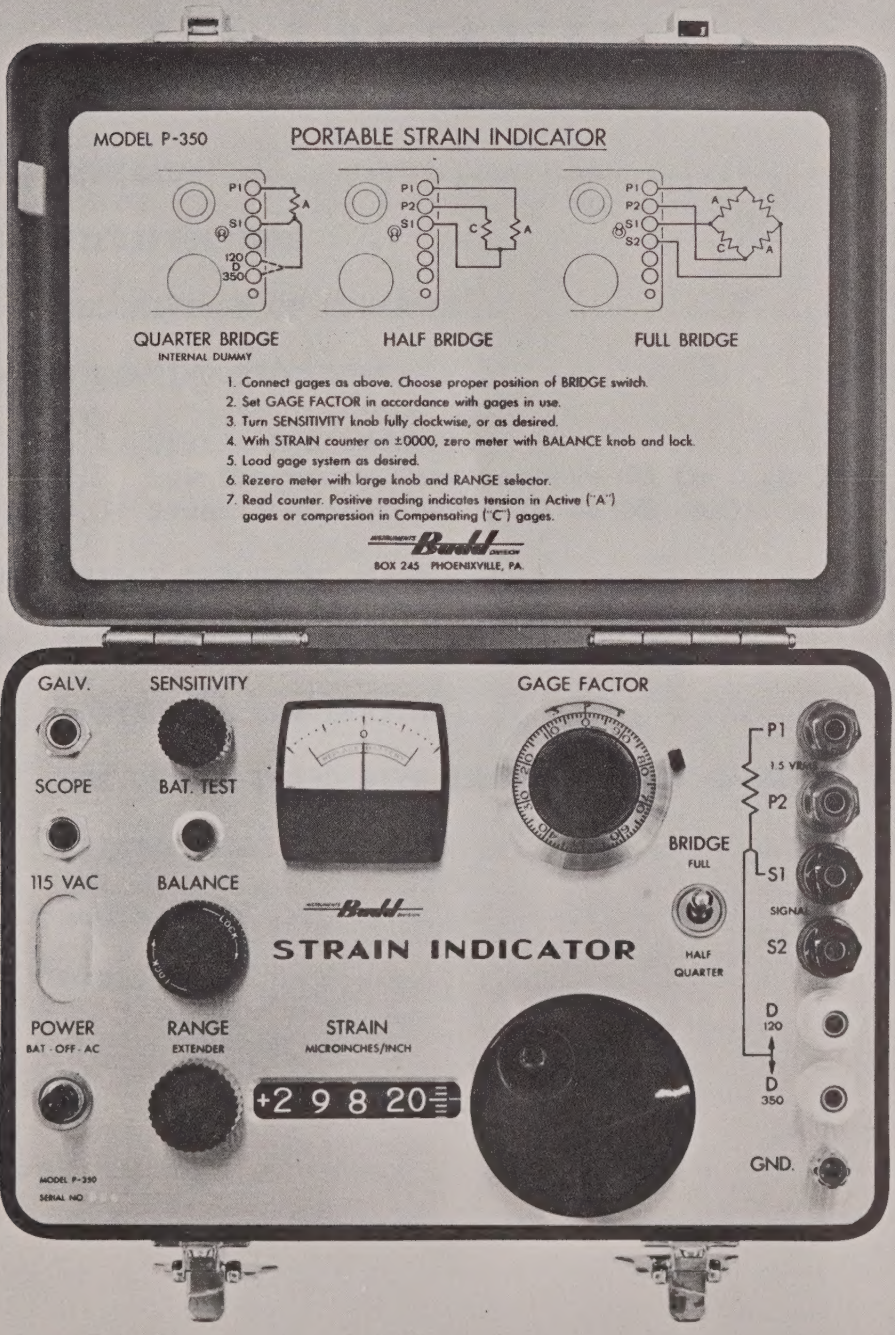


DIGITAL STRAIN INDICATOR (PORTABLE) MODEL P-350

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## 1.0 GENERAL

This instrument is designed primarily for use in determining static strain when used with resistance-type strain gages or strain-gage devices.

The operator must manually balance a null-meter before taking a reading. The following features make this instrument especially convenient in use.

1.1 Direct reading digital display provides an in-line readout of sign, range extension and strain rebalance knob.

1.2 Built in zero balance control assures direct indication.

1.3 Completely portable, lightweight, rugged and inexpensive.

1.4 Detachable cover for convenience.

1.5 Insensitive to lead wire capacitance.

1.6 Built in 120 and 350 ohm dummies for true quarter bridge operation.

1.7 Adjustable gage factor from 0.10 to 10.0 affording direct readout of any parameter.

1.8 Adjustable sensitivity for convenient dynamic operation.

## 2.0 SPECIFICATIONS (P-350)

| | | |
|---|---|---|
| 2.1 | RANGE | - ±50,000 microstrain. 10,000 microstrain on the primary balance knob. Polarity and range extension both on the RANGE EXTENDER knob. Total reading in single digital display. |
| 2.2 | ACCURACY | - ±0.1 percent of reading or 5 microstrain, whichever is greater, for R = 120 ohms and G.F. = 2.00.<br><br>For a 120-ohm bridge, G.F. from 1.5 to 4.5, accuracy shall be 0.3 percent of reading or 5 microstrain, whichever is greater.<br><br>For 50 to 2000-ohm bridges, G.F. from 1.5 to 4.5, accuracy shall be 0.5 percent of reading, or 5 microstrain, whichever is greater. |
| 2.3 | SENSITIVITY | - Variable Null balance meter deflects from zero to full scale with 40 to 2000 microstrain (nominal with G.F. =2.00). |
| 2.4 | READABILITY | - 1 microstrain. |
| 2.5 | GAGE RESISTANCE | - 50 to 2000 ohms. |
| 2.6 | BALANCE | - 10-turn lock knob provides approximately ±2000 microstrain (G.F. 2.00) for zeroing the digital readout prior to load application. |

| | | |
|---|---|---|
| 2.7 | GAGE FACTOR | - Continuously variable from 0.10 to 10.00 (calibrated between 1.50 and 4.50 only). |
| 2.8 | EXTERNAL CIRCUITS | - Full, Half, or Quarter Bridge; internal dummy gage for 120 and 350 ohm 3-wire circuits. |
| 2.9 | AMPLIFIER | - AC transistorized. |
| 2.10 | BRIDGE EXCITATION | - 1.5 volts RMS, 1000 cps square wave. |
| 2.11 | LEAD WIRE CAPACITANCE EFFECT | - Typically less than .05% loss of accuracy with .005 microfarads. Negligible effect with 500 feet of lead wire. |
| 2.12 | OSCILLOSCOPE JACK | - Full scale ±200 mv D.C. Sensitivity variable from approximately 0.4 to 20 $\mu\varepsilon$/mv |
| 2.13 | GALVANOMETER JACK: | - Full scale ±1/2 ma unfiltered D.C. Sensitivity variable from approximately 40 to 2000$\mu\varepsilon$/±1/2 ma. |
| 2.14 | BATTERY | - 9 Volts. Life approximately 200 hours (RCA VS301, or equal.) |
| 2.15 | CASE | - Aluminum - dust and spray tight. |
| 2.16 | WEIGHT | - 7 Pounds. |
| 2.17 | SIZE | - 9" x 6" x 6". |

## 3.0 DESCRIPTION OF CONTROLS

**3.1 Rebalance Knob & STRAIN Counter** - Used to bring the Null Meter to "0" in making a strain measurement - the Counter then displaying the strain in microinches per inch (microstrain). The knob has a range of 10,000 microstrain. The basic calibration assumes a single active strain-gage.

**3.2 RANGE EXTENDER** - Used to change sign (for tension or compression readings), and to extend the range of the Rebalance Knob in increments of 10,000 microstrain.

**3.3 BRIDGE Selector** - Used to switch the internal dummy half-bridge into the circuit for quarter and half-bridge applications.

**3.4 BALANCE Control** - Used to compensate to zero the initial unbalance in a gage circuit, (up to 2000 microstrain). Subsequent readings then are direct-reading "Indicated Strain." The control should be locked after adjusting on a given strain-gage installation.

**3.5 GAGE FACTOR Dial** - A 10-turn locking control used to set the appropriate Gage Factor. This control can be varied from nominally 0.10 to 10.00

**3.6 Null Meter** - A zero-center galvanometer used to determine instrument balance in adjusting the BALANCE and Rebalance knobs.

Normally all readings are taken with the pointer on "0", although other applications exist (see paragraph 3.7.) It is also used to check the condition of the internal battery.

3.7 SENSITIVITY Control - A gain control for the amplifier driving the Null Meter. The control can vary the sensitivity of the meter by a factor of at least 50:1. Normally this control is turned fully clockwise to yield a Null Meter sensitivity of approximately 40 microstrain full-scale in either direction.

At lower settings of the control the Null Meter itself can be used for direct strain readout of static or dynamic data up to 1 cps.

The SENSITIVITY Control is also used in conjunction with the SCOPE output jack for true dynamic measurements.

3.8 BAT. TEST Pushbutton - With the POWER switch on "BAT.", depressing this pushbutton will deflect the Null Meter to indicate battery condition.

Although a weak battery in this instrument does not directly affect accuracy, the Null Meter may become insensitive.

With the POWER switch on "AC", the BAT. TEST push-button checks the DC output of the AC supply, if installed. In this case, a "Replace Battery" reading indicates either a defective power supply or a disconnected line cord.

3.9 **POWER Switch** - The only ON-OFF switch on the instrument. Pushed to the left, the instrument will operate on the internal battery. Pushed to the right, it will operate on the LINE power supply. On battery operation, the unit is automatically shut off when the lid is closed.

3.10 **Binding Posts** - For attachment of lead-wires to the strain gage(s) or transducer. The hook-up for a single gage is marked on the panel. Other typical arrangements are shown on a brief instruction plate attached to the inside of the instrument cover.

3.11 **GALV. Jack** - Permits the diverting of the unfiltered DC current input to the instrument's Null Meter to a meter external to the instrument. An external meter of ±1/2 ma, 100 ohms is suggested.

3.12 **SCOPE Jack** - Provides filtered DC for a high-impedance indication or recording of dynamic strain. The source impedance is 12,000 ohms (recommended load: 1 megohm). The internal Null Meter becomes inoperative. The linear output is approximately 0 to ±200 millivolts, which (depending on the setting of the SENSITIVITY control) represents nominally ±80 to ±4000 microstrain (0.4 to 20 microstrain per millivolt). Frequency ranges from DC to 50 cps.

3.13 **115 VAC Receptacle** - Accessible when the internal AC supply is installed. The receptacle receives the female end of the detachable 3-wire line cord.

## 4.0 OPERATING PROCEDURE

### 4.1 Static Measurements

4.1.1 Connect the gage(s) as shown on the plate inside the lid.

4.1.2 Select the proper position of the BRIDGE selector, FULL or HALF/QUARTER.

4.1.3 Set the GAGE FACTOR dial as desired for the particular gage and/or application and lock.

4.1.4 Turn the SENSITIVITY knob full clockwise (for maximum meter sensitivity).

4.1.5 Turn the large rebalance knob counterclockwise to a STRAIN counter reading of "0000."

4.1.6 Turn the RANGE EXTENDER knob to "+" (without digit).

4.1.7 Push the POWER switch to BAT. or AC. The latter will require installation of the 115 vac line cord.

4.1.8 With a No-Load condition on the test specimen turn the BALANCE knob to null (zero) the Null Meter (clockwise to move the pointer to the right). Lock the knob.

If it is impossible to null the Meter using the BALANCE Control, lock the control in any position and use the large Rebalance knob to obtain the null in accordance with paragraph 4.1.10. Record the STRAIN Counter sign and reading of this NO-LOAD condition. Resume instructions with paragraph 4.1.9.

4.1.9 Load the test specimen as desired. Prior to the application of load it is assumed, for the procedures that follow, that the Null Meter has been nulled only by use of the BALANCE Control.

4.1.10 If the Meter has deflected to the left, rotate the large Rebalance knob clockwise until the Meter comes to null. Read the STRAIN counter and sign.

If the Meter remains to the left at full counter reading, rotate the RANGE EXTENDER knob clockwise until the Meter pointer moves to the right, then rotate the large Rebalance knob counterclockwise to null.

If the Meter has deflected to the right, turn the RANGE EXTENDER switch counterclockwise until the Meter pointer moves to the left. Then rotate the large Rebalance knob clockwise to obtain a Meter null. Read the STRAIN counter and sign.

4.1.11 The STRAIN Counter reading (nulled meter) is the "Indicated Strain." A "+" quantity indicates tension in the "Active" gages, a "-" quantity indicates compression.

For those No-Load cases where the Null Meter could be nulled only by use of the large Rebalance knob, a pretest STRAIN counter sign and reading were obtained for zero load.

The test load should now be applied and the Meter nulling procedures repeated using the Rebalance knob. Under these conditions, the "Indicated Strain" is determined from the following with due regard to signs:

Indicated Strain = (Final Reading) - (No-Load Reading)

4.2 Low-Frequency Measurements (Static to 1 cps)

Occasionally there are situations in which a strain level is fluctuating at a slow rate, but too rapidly for an operator to maintain null on the Null Meter. In these cases a simple technique is available to obtain data without additional equipment. (Accuracy better than 5 percent.)

4.2.1 Under static conditions (by use of a separate gage installation, if necessary), turn the SENSITIVITY Control to approximately its mid-point.

4.2.2 Bring the Null Meter to exact null with the Rebalance knob. Note the STRAIN reading and sign.

4.2.3 Rotate the Rebalance knob (in either direction) that number of microstrain from the noted reading which you desire to represent full scale on the Meter (usually a round number, such as 500).

4.2.4 Adjust the SENSITIVITY Control so that the Meter deflects previsely to the Full-Scale mark.

4.2.5 Return to the original setting and re-zero using the BALANCE Control.

4.2.6 Return to the full scale setting and readjust the SENSITIVITY Control to give an exact full scale indication.

4.2.7 The Null Meter is now calibrated so that strain readings can be taken directly from the meter (in the example, each meter division now represents 50 microstrain). The strain level representing zero meter deflection (needle point at "0") can be adjusted with the Rebalance knob.

This system is limited to frequencies of less than 1 cps because of meter damping and visual limitations.

4.3 Dynamic Measurements (Static to 50 cps)

For higher frequency dynamic measurements the Portable Strain Indicator is used in conjunction with an oscilloscope or high-input-impedance oscillograph.

Since the source impedance of the SCOPE jack is approximately 12,000 ohms, it is recommended that the oscilloscope or oscillograph input impedance be above 100K, preferably 1 megohm.

While the maximum output of the SCOPE jack is approximately ±500 millivolts, it preferably should be used to only ±200 millivolts to maintain good linearity.

Depending on the setting of the SENSITIVITY Control, the scale factor for the SCOPE output can be varied from approximately 0.4 to 20 microstrain per millivolt. This range provides adequate flexibility for measuring low or high amplitude dynamic strains.

The output can be used for measuring small dynamic strains superimposed on large static strains. In this case the static level is balanced out with the Indicator using the large Rebalance knob and RANGE EXTENDER until the dynamic trace of the strain is displayed symmetrically about the zero DC output level of the SCOPE jack.

Calibration of the SCOPE output can be achieved with either shunt calibration across the active strain gage)s) or by use of the large Rebalance knob on the Indicator.

## 4.4 Detachable Cover

The instrument as supplied is equipped with hinges which will allow removal of the cover. To effect removal, bend the open-sided portion of the cover hinge upwards far enough to clear the center section of the body hinge. If you prefer a permanently attached cover, please disregard these instructions.

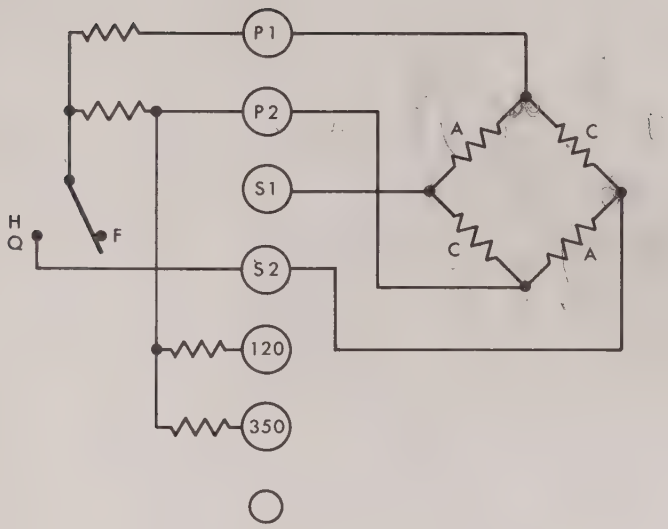
## 5.0 BRIDGE CIRCUITS

5.1 The Portable Strain Indicator readily adapts to various bridge circuits, but it is important to note that a basic condition for proper operation requires that the instrument must always have a four-arm bridge (internal or external) at the input and this bridge must have certain symmetry. Some forms of this bridge are theoretically linear but most are non-linear, although the non-linearity can usually be neglected.

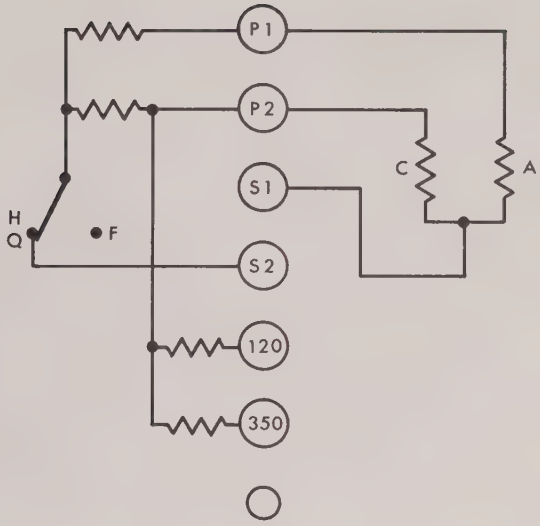
The most common forms of bridge hook-up for strain measurements are shown in Figure 1.

5.2 Good strain-gage practice dictates the use of three-wire quarter-bridge circuits. However, the P-350 can be used with two-wire circuits.

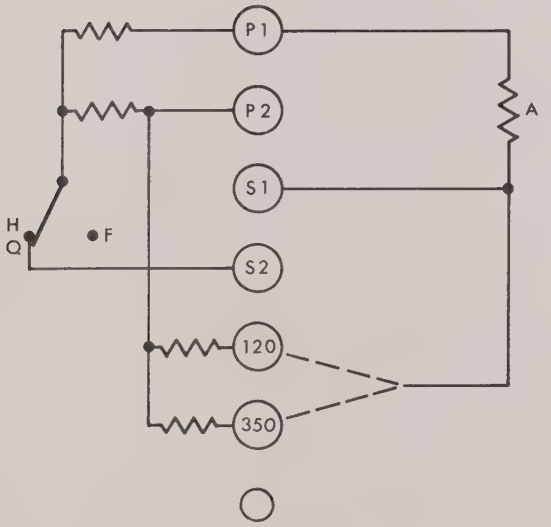
For single gage (quarter-bridge) two-wire installations, short together terminals S1 and D at the Indicator. Due to the high temperature coefficient of resistance of copper wire, ambient temperature changes on the lead wires can give a large false indication of strain. (Using 100 feet of twisted pair AWG #28 wire to a 120-ohm gage, the error would be approximately 1000 microstrain for a 10°F change). The recommended three-wire system puts half of the temperature induced lead wire resistance change in series with the dummy gage while the other half remains in series with the active gage. Equal changes in lead resistances in these adjacent arms then do not affect the strain measurement.



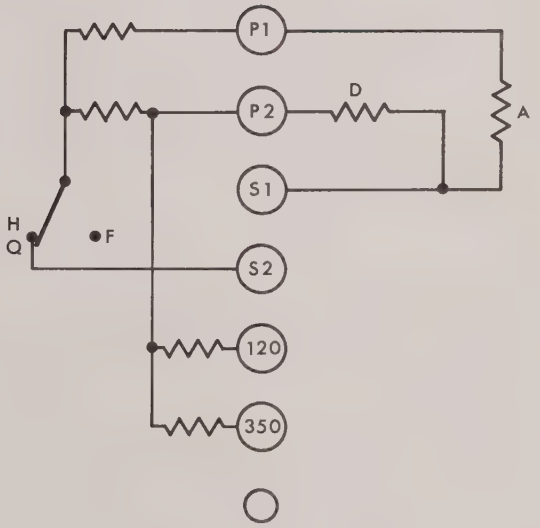

FULL BRIDGE




HALF BRIDGE




QUARTER BRIDGE
(INTERNAL DUMMY)




QUARTER BRIDGE
(EXTERNAL DUMMY)

FIGURE 1: COMMON BRIDGE CIRCUITS

## 6.0 GAGE FACTOR EQUATIONS

6.1 Definition - Gage Factor is a term used to relate the electrical sensitivity of a strain gage to strain; specifically it is the percent change in resistance for a percent change in length (or "strain"). For example, a G.F. of 2.00 means the gage changes 2 micro-ohms per ohm of initial resistance for a strain of 1 microinch per inch. Generally, the GAGE FACTOR dial on the Indicator should be set at the exact Gage Factor given by the manufacturer for the particular gage in use.

6.2 The GAGE FACTOR dial can be used to compensate for certain situations not directly defined as Gage Factor.

### 6.2.1 DESENSITIZATION

Care must be taken in strain gage work to avoid excessively long lead wires. The resistance of the leads appear in the strain gage bridge and this resistance does not change with strain. As a result the overall bridge circuit is desensitized. The following equation can be used to compute a corrected gage factor taking this desensitization into consideration:

$$GF_i = \left( \frac{Rg}{R_L + R_g} \right) GF \qquad (1)$$

where: $GF_i$ = the corrected "GAGE FACTOR" to be used on the Indicator

$Rg$ = the nominal gage resistance

$R_L$ = the lead-wire resistance (see below)

$GF$ = the original gage factor (from package)

For a two-wire quarter-bridge installation, $R_L$ is the total lead-wire resistance; but for three-wire quarter bridge circuits it is the resistance of <u>one</u> lead only.

### 6.2.2 HALF BRIDGE CORRECTION

The GAGE FACTOR dial can also be used in Half-Bridge circuits where a "Compensating" gage is placed at right angles to the "Active" gage in a uniaxial stress field. In this situation the "Compensating" gage will be partially active due to Poisson's Ratio and will cause the Indicator to read higher strains. The following equation can be used to compute the composite gage factor:

$$GF_c = GF\ (1 + \mu) = GF_i\ (1 + \mu)$$

where: $GF_c$ = the COMPOSITE "GAGE FACTOR" to be used on the Indicator

$GF$ and $GF_i$ = (defined in preceding equation)

$\mu$ = Poisson's Ratio for the particular material on which the gage(s) are installed (typically 0.25 to 0.35 in metals)

### 6.2.3 CANTILEVER COMPENSATION

If there are two gages in a half-bridge configuration bonded to opposite sides of a cantilever beam, the Indicator will read twice the strain seen by either gage. To determine the single average strain of one side, the Indicator reading may be divided by 2, or, alternately, the "Composite Gage Factor", $GF_c$ may be used:

$$GF_c = GF \times 2$$

In this case the instrument will then read directly the average strain indicated by each gage. Symbols are as defined above.

### 6.2.4 FULL BRIDGE CORRECTION

In full-bridge circuits $GF_c$ may be calculated for four active arms (6.2.2) or for two right angle pairs (6.2.3).

### 6.2.5 TRANSDUCER READOUT

Using transducers, the span is generally expressed in "millivolts per volt". This is the output in millivolts for an input of 1 volt at full rated mechanical input.

The corrected gage factor for direct transducer readout is computed as follows:

$$GF_T = 4000 \frac{k}{T_R} \qquad (2)$$

where: $GF_T$ = the Transducer GAGE FACTOR to be used on the Indicator

4000 = a constant

k = the transducer sensitivity in mv/v

$T_R$ = Transducer Rated capacity (pounds, psi, etc.)

Set $GF_T$, calculated above, to three significant figures on the GAGE FACTOR dial in the range from 0.10 to 9.99. Make the appropriate decimal placement at readout.

EXAMPLE:

Transducer: A 200,000 pound tension link with a 2 mv/v output at rated full load.

$$GF_T = 4000 \frac{k}{T_R}$$

$$GF_T = 4000 \frac{2}{200,000}$$

$$GF_T = 0.04$$

Therefore, either 0.40 or 4.00 could be set on the GAGE FACTOR dial and the STRAIN Counter reading multiplied by 10 or 100 respectively to yield pounds directly. Using $GF_T$ = 0.40 full load would give a STRAIN counter indication of 20,000, giving best sensitivity and readability. Using $GF_T$ = 4.00 full load indication is 2000 counts.

The corrected gage factor for direct transducer readout can also be experimentally determined as follows.

With the transducer installed in an experimental apparatus and connected to the P-350 adjust the SENSITIVITY control full clockwise.

Set the GAGE FACTOR dial at 2.00.

With an indication of "+0000" null the meter with the BALANCE control.

Apply a load.

Rebalance using the COUNTER knob.

Note the reading.

Then:

$$\text{LOAD} = \frac{\text{INDICATOR READING}}{2K} \times T_R \times 10^{-3}$$

Set the COUNTER to indicate determined load.

With the load applied, set the GAGE FACTOR control as required to null the instrument.

The system is now calibrated.

This latter technique results in a more accurate calibration.

## 7.0 INSTRUMENT CALIBRATION

The P-350 calibration is performed with accurately calibrated Metalfilm strain-gage networks. Since the calibration is functionally related to the resistance values of few stable components the instrument's accuracy is insured for many years of normal usage.

7.1 Should there be any question of accuracy, the following shunt-calibration technique is recommended. It should be noted that the determined accuracy will only be as good as the components used. The 1 kc square-wave excitation must be considered in this selection.

7.1.1 Set up the 120-ohm half-bridge circuit shown by Figure 2:

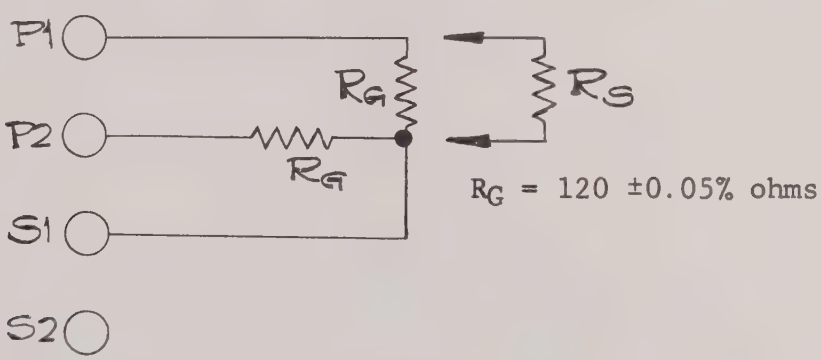



FIGURE 2: CALIBRATION CIRCUIT

7.1.2 With the STRAIN Counter set at +0000, zero the Null Meter using the BALANCE Control knob.

7.1.3 Shunt $R_g$ with $R_s$ as

7.1.4 Using the Rebalance knob, re-zero the Null Meter and note the sign and reading on the STRAIN counter. Compare this reading with the following computed reading:

$$\epsilon_1 = \frac{-2\,Rg}{GF_i(2Rs+Rg)}\,10^6 \qquad (3)$$

where: $\epsilon_1$ = the indicated strain (microstrain in compression)

$Rg$ = the nominal gage resistance in ohms

$Rs$ = the shunt resistance in ohms

$GF_i$ = the GAGE FACTOR to be set into the Indicator (computed in accordance with the equation in section 6.0)

The Indicator STRAIN Counter reading and the computed reading should match within specified accuracy limits.

7.1.5 To compute Rs for a desired STRAIN Counter reading, the above may be rearranged to:

$$Rs = \frac{10^6 Rg}{(GF_i)\,\epsilon_i} - \frac{Rg}{2} \qquad (4)$$

7.2 It may be noticed that the latter equation is similar to the standard "shunt-calibration" equation often used to simulate a given strain in a gage (the same circuit applying), viz:

$$R_c = \frac{10^6 Rg}{(GF_g)\epsilon_s} - Rg \qquad (5)$$

where: $R_c$ = the shunt "calibration" resistor in ohms

$Rg$ = the gage resistance in ohms

$GF_g$ = the Gage Factor of the specific strain gage

$\epsilon_s$ = the desired simulated strain in microstrain

The distinction between equations (4) and (5) is that the second simulates the action of an ideal strain gage under compressive strain, whereas the first refers to the reading on the Indicator. While it would be desirable that the results of these equations be the same, this is unfortunately not practical with any known commercial Indicator employing fixed bridge excitation. The errors introduced are generally small compared to other experimental errors in typical applications.

7.3 An expression can be developed to compute this error:

$$\varepsilon_g = \varepsilon_i \quad \frac{1}{1 - \left(\frac{GF}{2}\right)\varepsilon_i \times 10^{-6}} \qquad (6)$$

where: $\varepsilon_g$ = the strain at the gage in microstrain

$\varepsilon_i$ = the Indicated STRAIN from the counter (retain sign)

GF = the Gage Factor of the strain gage and the GAGE FACTOR value to be set into the Indicator

This error does not occur in bridge circuits where the current in each leg is kept constant; i.e.: fully active half-bridge and full-bridge circuits.

## 8.0 USE OF THE P-350 WITH SEMICONDUCTOR GAGES

While the P-350 Indicator is not designed for use with semi-conductor gages, it is possible to use these gages if certain corrections are made.

8.1 Gage Factor - The Gage Factor of semi-conductor gages is usually between 50 and 200, far beyond the range of the P-350's GAGE FACTOR control. It is possible, however: to divide the actual $GF_g$ by a "scaling ratio" of 5, 10, or 20; to use this new $GF_i$ as the GAGE FACTOR setting; and to divide the final result by the original scaling ratio.

8.2 Non-linearity - Due to the very high Gage Factor of semi-conductor gages, installations with a single active gage become quite non-linear. The following equation can be used to correct this error:

$$\varepsilon g = \frac{\varepsilon i}{k} \quad \frac{1}{1 - \left(\frac{GF_i}{2}\right) \varepsilon_i \times 10^{-6}} \qquad (7)$$

where: $\varepsilon_g$ = the calculated strain at the strain gage in microstrain

$\varepsilon_i$ = the microstrain sign and reading from the Indicator's STRAIN counter.

$k$ = the "scale ratio"

$GF_i$ = the GAGE FACTOR used on the Indicator, $= \frac{GF_g}{k}$

$GF_g$ = the Gage Factor of the specific strain gage

Equation (7) assumes linear operation of the semi-conductor strain gage, which is not always the case.

## 9.0 MAINTENANCE

Within the warranty period, the only maintenance procedure which does not void the instrument warranty is the periodic battery replacement. In the event of an electronic or mechanical malfunction during this period contact your nearest field sales office or the Field Service Department at Phoenixville, Pennsylvania.

## 9.1 BATTERY REPLACEMENT

Remove the four screws from the underside of the case and remove the instrument from its case. The battery is held in position by two metal bars. Unplug the electrical connection and loosen the screws holding the retainer bars to lift out the battery. Reverse the procedure to fit the replacement battery.

9.2 If the battery checks good yet the Indicator is totally inoperative:

9.2.1 Check for the 1.5 AC voltage between Terminals P1 and P2. If not present, replace Oscillator transistors Q5 and Q6 the positions of which are shown in Figure 3. If there is still no AC, replace Regulator transistor Q7.

9.2.2 If AC voltage is present at P1 and P2 but the Null Meter does not deflect, check that the "normally closed" contacts on the GALV. and SCOPE jacks are making electrical contact.

9.2.3 If the Null Meter still does not deflect or is poor in sensitivity, replace Amplifier transistors Q1, Q2, Q3 and/or Q4.

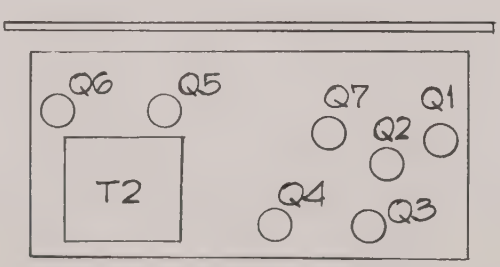



FIGURE 3
TRANSISTOR LOCATIONS ON OSCILLATOR/
AMPLIFIER BOARD, RIGHT END SIDE OF INSTRUMENT

9.3 If the large Rebalance knob tends to slip in driving the STRAIN Counter, loosen the two set screws in the hub of the large gear on the potentiometer shaft, then slide the gear to the desired frictional contact with the rubber-tired roller on the Rebalance knob shaft. To maintain accuracy tighten the gear set screws with the Rebalance knob mechanical stop and a STRAIN Counter reading of 0000 at exact coincidence.

9.4 In the event of electronic or mechanical malfunctioning not covered by the maintenance procedures described above, contact the "Field Service Department."

## 10.0 ACCESSORIES

P-350 WITH AC POWER SUPPLY AND COUNTING BALANCE KNOB

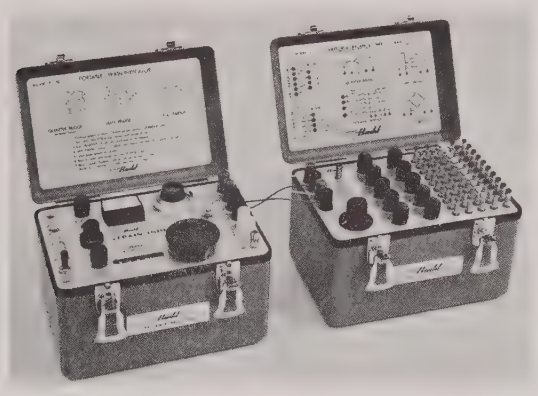
### 10.1 INTERNAL AC POWER SUPPLY (MODEL A1-P-350)

An AC Power Supply is available for the P-350. This accessory can be installed in the field with only a screw driver. The Power Supply permits the P-350 to be operated either from its internal battery or from a 115 vac line. A line cord is furnished as a part of the accessory. Instructions for installation are furnished in each kit. Order Part Number 120-000744.

### 10.2 COUNTING BALANCE KNOB (MODEL A2-P-350)

A concentric-dial counting knob is available for the BALANCE control on the P-350 replacing the standard knob. The accessory facilitates repeat settings of this control for measurements taken at different times on the same strain-gage installations. Part No. 120-000745.

## 10.3 SWITCH AND BALANCE UNIT(MODEL SB-1)



P-350 WITH SB-1 SWITCH AND BALANCE UNIT

A 10-point Switch and Balance Unit is available as a companion instrument in a similar case which provides for 10 separate strain-gage channels (quarter, half, or full bridges) with individual initial-balance controls for each channel and a selector switch to select the desired channel. Quick-connect gold-plated "Push-Posts" are used for gage connections. Part Number 120-000584.

## 10.4 SWITCH UNIT (MODEL S-1)

A 10-point Switch Unit is available as a companion instrument in a similar case. It is an economy version of the Model SB-1. Initial-balance controls are not provided and gage connections are made on screw-type terminals. Quality and accuracy are equal to those of the Model SB-1, but it is not as convenient to use.

Part Number 300-042918.

S-1 SWITCH UNIT

[illegible]

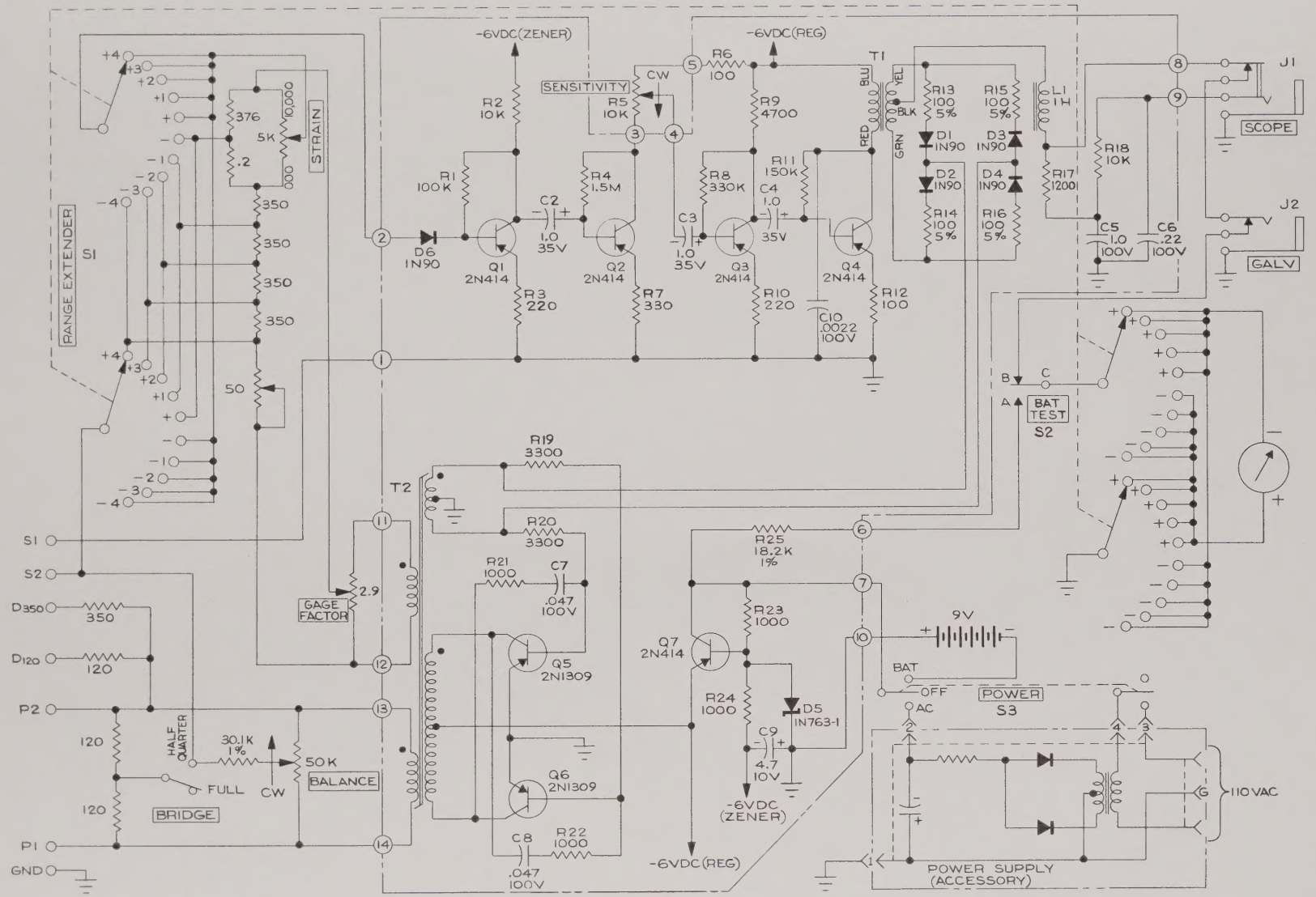
## 11.0 PARTS LIST

The following maintenance and repair parts are available:

| Description | Part Number |
|---|---|
| Battery, 9V | |
| Burgess D6P1 Malloy M-1601 | |
| Eveready 2506 Ray-O-Vac 1601 | |
| RCA VS301 NEDA 1601..... | 23X100010 |
| Transistors | |
| Q1 through Q4 & Q7 2N414..... | 14X200007 |
| Q5 & Q6 2N1309..... | 14X200045 |
| Null Meter ..... | 152-012774 |
| Plug (GALV. or SCOPE Jacks) | |
| "Switchcraft" #240, or equivalent .... | 12X700024 |
| Line Cord (spare) for A.C. Power Supply .. | 21X900039 |

For repairs or replacements involving parts other than the above, please write or contact the Factory for instructions. Inquiries should be addressed to: "Field Service Department."

Budd
STRAIN INDICATOR




300-042942 REV "C"

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|---|---|---|---|---|---|
| DRAWN DELTUFFO | DATE 4-8-64 | CHECKED | DATE 4-6-64 | NUMBER 300-042942 | |
| DESIGNED | DATE | APPROVED | DATE 6-15-64 | TITLE SCHEMATIC | INSTRUMENTS Budd DIVISION |

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